Capital Markets Review Vol. 25, No. 1, pp. 43-62 (2017)

The Relationship of Crude Palm Oil Spot-Futures under Inflationary Expectation in Gold Market

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Abstract: This study attempts to test whether the direction of information spillover between crude palm oil (CPO) spot and futures price corresponds to a long-term shift in gold price. While there is yet to be a study on the CPO spot-futures relationship under the inflationary expectation of gold price, this paper hypothesizes that market participants are bullish on gold price will use the commodity as an inflation hedge, and this put speculative pressure on future CPO price. Using daily data on CPO spot and futures returns from January 1996 to November 2011, notably, it is found that: First, there is volatility spillover from current futures return to spot return during bullish period in gold due to increase in investor demand; Second, only contemporaneous volatility spillover between spot and futures returns exist during bearish period as investors become more risk averse. This study adds to another stylized fact that the upward trend of the gold price has economic content that leads to speculation of CPO price in the futures market.

Keywords: Crude palm oil, gold trend, spot-futures relationship, information spillover, causality-in-variance.
JEL classification: E31, G1, G13

1. Introduction

The inflationary expectation provides speculative opportunities in the futures market of commodities. Since the futures price is derived from the spot price of an underlying commodity, it provides information about market participants' expectation of future spot prices and opportunities for price manipulation of a commodity. The reason is intervention in the futures market can influence producers' decision in the commodity spot market. According to Newberry (1992), market participants tend to change their investments from common stocks, bonds or equities to commodity markets in order to face the expected inflation.

Based on the study by Mahdavi and Zhou (1997), they find that commodity prices are often thought to incorporate arrival of new information faster than consumer prices. Meanwhile, Twomey *et al*. (2011) further demonstrate that commodities can be used to hedge against unexpected inflationary shock during the sample period of 1980-2011. The expected increases in a commodity price will provide opportunities for market participants to speculate the price of a commodity through the futures market.

Several researchers such as Jaffe (1989), Narayan *et al*. (2010), Beckmann and Czudaj (2013), and Shahbaz *et al*. (2014) present various aspects of the role of gold in preserving price stability. For instance, Jaffe (1989) who finds that investors can hold gold as an alternative for a stock to hedge against inflation. Using the cointegration test, Narayan *et al*. (2010) find that futures markets of oil and gold are cointegrated at the maturities of a ten-

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month contract during 1995-2009. Their findings suggest that investors transfer funds from stock market to gold market to hedge against inflation and secure profitability in their investment. As a consequence, a higher demand for gold will increase the gold price.

Using a Markov-switching vector error correction model, Beckmann and Czudaj (2013) find that the gold has the ability to hedge the future inflation in the United States and the United Kingdom as compared to Japan and Euro Area, respectively. This implies that the gold cannot consistently provide an inflation hedge over time due to the occurrence of various economic turbulences at different time horizons. Based on the results of autoregressive distributed lag (ARDL) bounds testing approach, Shahbaz *et al*. (2014) find that the gold price can provide a good investment to hedge against inflation in Pakistan during the sample period of 1997-2011.

Based on the existing findings, the upward movement of gold price can be used as an effective hedge against inflation in the long run, implying that an increase in expected inflation will encourage more people to invest in the gold. This leads to higher prices in gold and eventually influences the price movement of other commodities in the short run (Zhang and Wei, 2010).[1] In summary, the expected inflation will trigger higher demand for gold, and in return, a higher gold price can influence the price of other commodities.

There are some reasons for conducting this study in the case of Malaysian crude palm oil (CPO) markets. First, being the world's second largest producer of CPO, there is a growing demand for Malaysia to export CPO in form of biofuel and food to other emerging markets. To maintain a sufficient amount of commodity for biofuel and food consumption in the country, the Malaysian government has implemented the national policies related to energy and food.

To reduce the dependency on fossil fuel, the National Biofuel Policy was implemented on March 21, 2006, to promote the use of biodiesel derived from palm oil as environmentally friendly and sustainable energy source (Unites States Department of Agriculture Foreign Agricultural Service, 2014). On the other hand, the National Agro-Food Policy was launched on September 28, 2011, to alleviate the issue of income inequality and poverty by ensuring steady and resilient food related industries based on agricultural sector (Ministry of Agricultural and Agro-Based Industry Malaysia, 2014). As a result of implementing these policies, changes of CPO price would affect demand for refined palm oil related products, thereby providing the direct or indirect influence on consumption pattern of CPO and inflation.

Second, some studies on the role of gold as a hedge in the case of Malaysia are carried out from two perspectives. From the perspective of whether gold is a hedge or a safe haven in the stock market, Ghazali *et al*. (2013) perform systematic and conditional analyses using the daily data of 2001-2013 for domestic gold return (changes in the selling price of one troy ounce Kijang Emas) and stock return. Their results show that gold returns are negatively correlated with stock returns on average. This suggests that gold is a hedge. Meanwhile, its returns are mixed correlated with stock returns during financial stress, suggesting that the gold is a weak safe haven for stockholders. From the perspective of whether gold serves as a hedge against inflation, Ghazali *et al*. (2015) perform correlation and linear regression analyses using the daily data of 2001-2011 for domestic gold return and inflation. Their results show that the relationships between gold return and inflation, between gold return and expected inflation as well as between gold return and unexpected inflation are insignificant. In contrast, their finding suggests that a domestic gold price is not a good hedge against inflation.

[1] By using linear and non-linear Granger causality approaches, Zhang and Wei (2010) find that the United States crude oil spot and London gold spot prices are cointegrated during 2000-2008. From the perspective of volatility, a change in gold price movement is found as the main factor driving a change in crude oil price in the short run.

However, both studies overlook from the perspective of investor demand in the futures market point of view. Like those of other commodities, the spot-futures relationship for CPO in the short run is frequently determined by market participants' decision. Their decision either is to use CPO for the production purpose or hold a physical stock of such commodity for the speculation purpose based on their expectation of a subsequent price rise (Go and Lau, 2017). For those who have a high inflationary expectation, they tend to speculate CPO prices through the futures market by selling CPO futures contracts with higher prices to those who wish to acquire the physical stocks or inventories for CPO. This consequently provides a greater role of investor demand in the CPO futures market.

To our best knowledge, thus far, there is no clear attempt on this perspective previously. Hence, it would be interesting to investigate whether the movement of gold price plays the role of inflationary expectation with respect to the spot-futures relationship in the case of Malaysian CPO. Among the research questions are: How market participants of CPO futures react when there is a rising trend in gold price and vice versa? What is the underlying market mechanism that prompts producers of a commodity and hedgers to react in a certain manner?

Based on the behavioral finance point of view, in terms of an arbitrage mechanism, the associated rise or decline of the gold price leads to market participants to buy or sell CPO in spot and futures markets to gain excess revenue in the future inflation. As suggested by Kaufmann and Ullman (2009), Tilton *et al*. (2011), Bos and Van der Molen (2012), and Gulley and Tilton (2014), if market participants expect that the commodity futures price exceeds the current spot price, they would long futures contract to obtain riskless profits by buying a commodity now and holding in inventory until delivery in the future. This high inflationary expectation may lead to a rise of the arbitrage opportunity.

There are two contributions to this study: First, to investigate whether speculation on CPO prices exists under the bullish gold market that acts as an inflation hedge; Second, to determine the decision on the appropriate response of CPO market participants toward volatility of spot and futures returns given a certain gold market trend. This study attempts to adopt the parametric approach which is developed by Cheung and Ng (1996). This approach seems to be more appropriate in examining the causality-in-variance between CPO spot and futures returns under upward and downward trends for gold. The reason is it can detect non-linear causal relationship in mean (first moment) and variance (second moment) of both series based on cross-correlation functions of standardized residuals and their squares (Henry *et al.*, 2007).

The rest of this study comprises the background of Malaysian CPO spot and futures activities. The subsequent section is to explain on the theoretical framework. Then, it is followed by an explanation of data and methodology. The next section is to discuss the empirical results. The last section is to conclude the discussion and suggest the implications of this study.

2. Background of Malaysian Crude Palm Oil (CPO) Spot and Futures Activities

CPO is one of the agricultural commodities that have sufficiently high economic value for Malaysia, where it is recognized as the golden crop after rubber. In this regard, the palm oil industry plays the role as the Malaysian economy's backbone, making the country as the second largest world palm oil producer after Indonesia. As reported by Malaysian Palm Oil Board (2015), Malaysia has contributed to 39% of world production and 44% of world export for CPO in 2014.

According to Malaysian Palm Oil Board (2015), palm oil industry has accounted for 6% of Malaysian gross domestic product in 2014. The industry has contributed to a higher export of palm oil products over the last few years. For example, its total export has increased from 25.07 million tonnes in 2014 to 25.37 million tonnes in 2015 by 1.2%. However, a lower export price has led to declining total export revenue from RM63.62 billion in 2014 to RM60.17 billion in 2015 by 5.4%. Due to this, export revenue for palm oil has declined from RM44.50 billion in 2014 to RM41.26 billion in 2015 by 7.3%.

The palm oil industry is divided into two major sectors. First, the upstream sector involves activities such as cultivating palms for the production of fruit bunches in plantation and processing fresh fruit bunches in the mill. Second, the downstream sector involves activities in refining and separating unrefined palm oil products in obtaining solid stearin fraction and liquid olein. According to the Performance Management and Delivery Unit (2010), palm oil industry based on upstream activities contributes 81.5% of the total export of the Malaysian palm oil industry as compared to an industry based on downstream activities that only contributes 4%. Since a high demand for refined palm oil products from South Korea, Turkey, Vietnam and Japan, oleochemical exports from Malaysia have increased from 2.83 million tonnes in 2014 to 2.85 million tonnes in 2015 (Malaysian Palm Oil Board, 2015).

In 2005, Germany was the largest producer of biodiesel in the world with 1.6 million tonnes. Since the price of crude petroleum was recorded to be higher than U.S. Dollar 60 per barrel in 2006, many countries have started to seek renewable energy from vegetable oil. Palm oil has been successfully used as a biofuel because it is a viable and environmentally friendly. A low price of CPO during the period of August 2006 - June 2007 has made the biofuel industry in Malaysia viable. This has led to the percentage of palm oil production used for biofuel increased from 1% in 2006 to 7.9% in 2007 (Koizumi and Ohga, 2007). As a result, this made Malaysia became the world's second largest producer of biofuel in 2007 after Germany (European Biodiesel Board, 2007). However, a higher price of CPO in the subsequent period resulted in a thin profit margin which brought losses to the producers.

Given the prominence of such commodity to the Malaysian economy, CPO futures contract is introduced since October 1980 as the first derivative instrument to be traded under the platform of Kuala Lumpur Commodity Exchange (KLCE). In November 1998, KLCE merges with the Malaysian Monetary Exchange (MME) to become the Commodity and Monetary Exchange (COMMEX). Afterward, the COMMEX is named to be the Malaysia Derivatives Exchange Berhad (MDEX).

On April 17, 1993, the Bursa Malaysia Berhad and CME Group (Chicago Mercantile Exchange & Chicago Board of Trade) provide, operate and maintain futures and options exchange. Since the MDEX is 75% owned subsidiary of the Bursa Malaysia Berhad as compared to 25% owned subsidiary of the CME Group, the MDEX is renamed as the Bursa Malaysia Derivatives Berhad (BMD). Among derivatives exchanges around the world, palm oil related products are most popularly traded in the BMD.

In 1994, the CPO futures market has well performed as its trading volume increased by 59.5% as compared in 1993. Such performance has contributed to the palm oil production of 7,672 thousand tonnes and about half of the total world palm oil production of 14,507 thousand tonnes (Oil World, 2010).

On December 31, 2009, total CPO futures contract traded has increased from 3,003,549 contracts to 4,008,882 contracts steadily with the rising of demand from both China and India. From October 2010 to December 2010, CPO futures price was raised by 38% due to the declining CPO production from 17,564,937 tonnes to 16,993,717 tonnes (Malaysian Palm Oil Board, 2011).

From a trading point of view, CPO futures price acts as the global benchmark of CPO price for various reasons such as price risk management and speculation. For example, plantation companies, refineries, exporters, and millers use CPO futures contracts to manage their risk and hedge against the risk of unfavorable movement in CPO price in the physical market. On the other hand, speculators use CPO futures to take a view on the likely movement of future spot price which can lead to profits or losses depending on whether they get it right or not. Lastly, producers and other market intermediaries use it as a price indicator to assess the best CPO pricing.

3. Theoretical Framework

To prevent any arbitrage opportunity, Pindyck (2001) describes that the relationship between spot and futures prices for a commodity should hold as in Equation (1).

$$\psi_{t,T} = (1+r_T)S_t - F_{t,T} + k_T \tag{1}$$

where $\psi_{t,T}$ is capitalized flow of marginal convenience yield over the period t to $t + T$, S_t is spot price at time t, $F_{t,T}$ is futures price for delivery at time $t + T$, r_T is risk-free T-period interest rate, and k_T is the per unit cost of physical storage at time T.

This study attempts to test whether the direction of information spillover between CPO spot and futures prices corresponds to the long-term shifts in gold price. Hence, the following two hypotheses for respective gold market trend are stated as:

Hypothesis 1: When there is a continuous rise in the gold price (bull market), there will be volatility spillover from CPO futures returns to spot returns is due to increase in investor demand for CPO related products.

Hypothesis 2: When there is a continuous decline in the gold price (bear market), there will be contemporaneous volatility spillover between CPO spot and futures returns as driven by market participants who are risk averse.

According to *Hypothesis 1*, when the gold price increases, market participants will expect the CPO spot price to increase in near terms as there is a comovement between CPO and gold prices. When the futures price rises more than the spot price, the capitalized flow of marginal convenience yield in Equation (1) will be quite small. Higher CPO futures price relative to spot price will also lead to a higher volatility spillover from futures to spot market. In other words, high futures volatility will decrease storage demand and the option value of keeping the commodity, hence market participants will long CPO futures contracts in order to hedge the increase of CPO spot price. This allows producers to hedge against future price volatility by allocating their inventories to buffer any fluctuation in consumption of CPO in the next period.

After that, *Hypothesis 2* is set to state that participants with the bearish expectation of gold market tend to react to the shocks immediately toward downward risk by shorting the futures contracts. The explanation to support *Hypothesis 2* is a downward movement in the gold market will force market participants to relocate their resources from commodity to equity markets. This will cause a decline in CPO price and in contrast, an equity price will increase. The declining CPO price will cause storage costs to be insufficiently covered.

Under this situation, market participants will decide to sell the commodity to minimize their losses. Their decision consequently contributes to a high volatility of CPO spot price which is often the unpredictable shifts in the supply and demand that make production costs to be higher in the short run. When the spot price exceeds the futures price, the capitalized flow of marginal convenience yield of CPO will be usually high (as shown in Equation (1)). A higher capitalized flow of marginal convenience yield is often associated with holding CPO as inventories when option value of keeping the commodity increases with a higher volatility of CPO spot. In order to reduce production costs, market participants need greater storage and inventory of CPO to relocate their production in the short run.

4. Data

This study uses daily closing prices of CPO spot and futures from January 1, 1996 to December 30, 2011, as measured in Ringgit Malaysia (RM). When a futures contract draws closer to maturity, the heterogeneity between consecutive contract and unusual market activity are often observed to happen and generate significant biases in the various time-series properties of the artificial price series (Ma *et al.*, 1992).

To avoid the possible biases, the constant maturity contract is chosen to ensure that all prices are measured at the same point in time. Therefore, this study uses the daily price for 3-month futures contract because this contract is the most active and liquid contract traded in the futures exchange. Meanwhile, this study chooses the price of spot-month continuous contract because such contract can provide information on price movement in the long term.

The daily data of both prices are collected from the Thomson DataStream and Bursa Malaysia (refer to http://www.bursamalaysia.com). To reduce variation and achieve stationary movement, daily prices of CPO spot and futures are transformed into price changes in logarithmic terms (daily returns).

This study identifies upward and downward trends in the gold market based on turning points in the London gold price movement. This study chooses gold that traded in the London Bullion Market because it is the largest over-the-counter market in trading gold and silver in the world followed by New York, Zurich and Tokyo.

As observed in Figure 1, the downward trend (bear market) in the London gold price happens from January 17, 1996 to July 20, 1999. The sample period of this gold trend happens during the onset of the Asian financial crisis 1997-1998 and the post-Asian financial crisis in 1999. It is observed that an upward trend (bull market) in the London gold price happens from November 7, 2005, to November 30, 2011. As compared to the crisis and non-crisis periods, it is further observed that both CPO spot and futures prices tend to move together with the gold price across time.

The CPO futures price has an upward movement from 1998 onwards. The restructuring of the Malaysian derivative market to COMMEX in responding to the depreciation of Ringgit in November 1998 has seen the CPO futures contracts traded at RM2,700 per metric tonne, making palm oil as the top foreign exchange earner that exceeded the revenue derived from crude petroleum and petroleum products by a wide margin.

To reduce dependency on fossil fuel as well as to stabilize palm oil prices through export, research and development activities as outlined in the National Biofuel Policy was launched on March 21, 2006 (Unites States Department of Agriculture Foreign Agricultural Service, 2014). With this policy, the existence of bio-fuel for non-food usage in 2006 provided the most efficient pricing of CPO in the BMD. Consequently, CPO spot and futures prices have dramatically increased from 2006 to 2008 (as shown in Figure 1).

From March 2008 to October 2008, both CPO spot and futures prices have dropped to RM1,418 and RM1,390 per metric tonne, respectively. Such scenario illustrated that the global financial crisis 2008-2009 has translated into a high volatility in CPO price. This high volatility made both spot and futures markets to be more uncertain over time. However, during the period of post-global financial crisis, the decline in demand of commodity globally resulted in high unsold inventory and low price. Subsequently, both palm oil prices have decreased to RM2,400 per metric tonne in 2012.

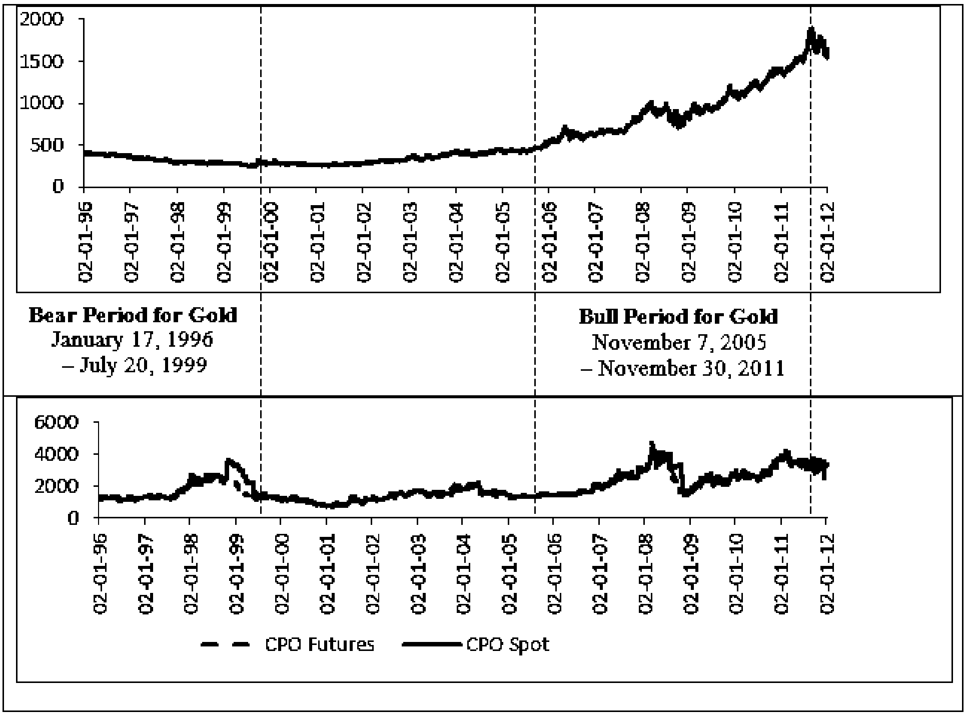

Figure 1: Daily CPO spot and futures prices during bull and bear markets for the London gold, 1996-2011.
Source: Bloomberg (2011).

Since volatility is recognized as a key determinant of the value of commodity-based contingent claims with market dynamics in the short run, so the preliminary step of this study is to compare volatility between CPO spot and futures returns. As shown in Table 1, a daily CPO spot return is slightly volatile than a daily CPO futures return during the gold bear market as reflected by their relative standard deviations. During a consecutive increase in the gold price, the volatility of CPO futures return is found to be slightly higher than the volatility of CPO spot return. This suggests that different movements of gold price in the long term lead to the presence of asymmetric information flow between CPO spot and futures returns.

Table 1: Descriptive statistics for daily CPO returns

	Gold bear: Jan 17,1996 - Jul 20, 1999		Gold bull: Nov 7, 2005 - Nov 30,2011	
	CPO spot	CPO futures	CPO spot	CPO futures
Mean	-0.0002	-0.0002	0.0005	0.0005
Maximum	0.0771	0.0508	0.0929	0.0950
Minimum	-0.0747	-0.0614	-0.1104	-0.1089
Standard deviation	0.0165	0.0156	0.0189	0.0196
Skewness	-0.1843	-0.2587	-0.3577	-0.2986
Kurtosis	4.8983	3.8584	7.2478	6.1234
Jarque-Bera	133.6745***	35.9005***	1144.2740***	623.5885***
Observations	858		1480	

Notes: The daily CPO spot and futures returns in the natural logarithmic form. ** *denotes significance level at the 1 %.

In addition, the Jarque-Bera test statistic provides a rejection of the null hypothesis of normality for both CPO returns. This non-normal distribution is further demonstrated by skewness and kurtosis, where both CPO returns in two different gold market trends are characterized by excess peaks that have kurtosis statistics to be substantially higher than 3. This characteristic in the data requires the use of generalized autoregressive conditional heteroskedasticity (GARCH)-type models to capture the volatility clustering of both CPO returns. This finding is consistent with those of Lean and Smyth (2015), who find that it is important to allow heteroskedasticity in CPO spot and futures returns when testing the efficient market hypothesis.

There present structural changes which correspond to the 1998 Asian financial crisis and the 2008 global financial crisis (as observed in Figure 1). To avoid obtaining biased test statistics toward the non-rejection of a unit root, the existence of a unit root of both CPO returns is tested using a non-parametric test, namely Phillips-Perron (PP) test.[2]

In Table 2, an auxiliary regression of this unit root test is specified in two ways. The first one is to include a constant term (drift) only. The second one is to include constant term and time trend. Using two different ways for the auxiliary model, this test supports the rejection of the null hypothesis of a unit root at the 1% level of significance, implying that both returns are stationary series in level form.

Table 2: Result of Phillips-Perron (PP) unit root test for daily CPO returns

	Gold bear : Jan 17,1996 - Jul 20, 1999		Gold bull : Nov 7, 2005 - Nov 30,2011	
	CPO spot	CPO futures	CPO spot	CPO futures
Constant	-26.5082***	-27.4438***	-39.1993***	-40.1398***
Constant & Trend	-26.6872***	-27.6250***	-39.1979***	-40.1367***

Notes: The daily CPO spot and futures returns in the natural logarithmic form. PP critical values are based on Mckinnon. The null hypothesis for the PP test is a series has a unit root (non-stationary). *** denotes significance level at the 1 %.

5. Methodology

This study attempts to employ the non-linear approach since volatility and structural breaks in the CPO price level may lead to a non-linear linkage. The non-linear approach employed is a cross-correlation function (CCF) proposed by Cheung and Ng (1996). This approach can detect non-linear causal relationship in mean (first moment) and variance (second moment) of both series based on CCFs of standardized residuals and their squares (Henry *et al.*, 2007). With a two-stage approach, CCFs have the ability to specify correctly the first moment dynamic (mean) and second moment dynamic (variance), detect significant causality of both series for a large number of observations at longer lags, and reveal useful information on the causality pattern (Cheung and Ng, 1996).

In the first stage, correlograms of the partial autocorrelation function (PACF) is used to determine appropriate orders for autoregressive (AR) that maximizes the log likelihood function. Meanwhile, the orders for moving average (MA) are determined using correlograms of the autocorrelation function (ACF). The further examination of ACF and PACF correlograms on squared residuals from the conditional mean equation is to check the existence of GARCH effect. The conditional mean equation (ARMA) and conditional variance equation (GARCH) for both CPO returns are written as below.

[2] Phillips and Perron (1988) develop the model that allows for testing a unit root in the presence of a structural change at a certain period (a detailed discussion can be seen in the books written by Davidson and MacKinnon (2004: 623) and Enders (2010: 229).

$$R_{S,t} = a_0 + \sum_{i=1}^{P1} a_i R_{S,t-i} + \sum_{i=1}^{P2} b_i \varepsilon_{S,t-i} + \varepsilon_{S,t}, \ \varepsilon_{S,t}|\phi_{t-1} \sim N(0, \sigma_{S,t}^2) \tag{2}$$

$$\sigma_{S,t}^2 = w + \sum_{i=1}^{P3} \alpha_i \varepsilon_{S,t-i}^2 + \sum_{i=1}^{P4} \beta_i \sigma_{S,t-i}^2 \tag{3}$$

$$R_{F,t} = a_0 + \sum_{i=1}^{P1} a_i R_{F,t-i} + \sum_{i=1}^{P2} b_i \varepsilon_{F,t-i} + \varepsilon_{F,t}, \ \varepsilon_{F,t}|\phi_{t-1} \sim N(0, \sigma_{F,t}^2) \tag{4}$$

$$\sigma_{F,t}^2 = w + \sum_{i=1}^{P3} \alpha_i \varepsilon_{F,t-i}^2 + \sum_{i=1}^{P4} \beta_i \sigma_{F,t-i}^2 \tag{5}$$

where $R_{S,t}$ is the daily CPO spot return at time t, $\sigma_{S,t}^2$ is the conditional variance for CPO spot return at time t, $\varepsilon_{S,t}$ is the unexpected CPO spot return that cannot be predicted based on all information available up to the preceding period, $R_{F,t}$ is the daily CPO futures return at time t, $\sigma_{F,t}^2$ is the conditional variance for CPO futures return at time t, and $\varepsilon_{F,t}$ is the unexpected CPO futures return that cannot be predicted based on all information available up to the preceding period.

Based on Equation (2) - Equation (5), the number of lags for the dependent variable, forecasted error, squared error and conditional variance is based on the minimum Schwarz information criterion (SIC). These univariate equations should adequately account and explain the serial correlation of the data in the first and second moments in order to produce stationarity of standardized residuals in level and square forms. For the level form, they are denoted as U_t and W_t, respectively. For the square form, they are denoted as U_t^2 and W_t^2, respectively. These standardized residuals are used further to compute a sample cross-correlation (r) between CPO spot and futures returns at lag k using Equation (6) and Equation (7).

$$r_{UW}(k) = \frac{C_{UW}(k)}{\sqrt{C_{UU}(0)C_{WW}(0)}} \tag{6}$$

$$r_{U^2W^2}(k) = \frac{C_{U^2W^2}(k)}{\sqrt{C_{U^2U^2}(0)C_{W^2W^2}(0)}} \tag{7}$$

where $r_{UW}(k)$ is the k th lag sample cross-correlation between standardized residuals for CPO spot and futures returns, $C_{UW}(k)$ is k-th lag sample covariance between standardized residuals for CPO spot and futures returns, $C_{UU}(0)$ is the sample variance of standardized residuals for CPO spot return, $C_{WW}(0)$ is the sample variance of standardized residuals for CPO futures return, $r_{U^2W^2}(k)$ is the k th lag sample cross-correlation between standardized residuals squared for CPO spot and futures returns, $C_{U^2W^2}(k)$ is k-th lag sample covariance between standardized residuals squared for CPO spot and futures returns, $C_{U^2U^2}(0)$ is the sample variance of standardized residuals squared for CPO spot return, and $C_{W^2W^2}(0)$ is the sample variance of standardized residuals squared for CPO futures return.

To examine whether feedback in mean (variance) between both CPO returns occurs at a specified lag k, a standard normal critical value is used to test the null hypothesis of no feedback effect (Cheung and Ng, 1996: 37). If the absolute value from Equation (8) is greater than the critical value, the hypothesis testing reveals that there exists feedback in mean at a specific lag k. The rejection of the null hypothesis of no causal effect in variance between both CPO returns is revealed when the absolute value from Equation (9) greater than the critical value.

$$\sqrt{T} r_{UW}(k) \xrightarrow{L} N(0,1) \tag{8}$$

$$\sqrt{T} r_{U^2W^2}(k) \xrightarrow{L} N(0,1) \tag{9}$$

In the second stage, the resulting feedback in mean and variance are used further to reconstruct respective univariate equation (Equation (2) - Equation (5)) by adding the relevant lagged CPO returns and lagged squared CPO return. For example, to capture feedback in mean, lagged CPO futures and spot returns in the level form $\left(R_{F,t-i} \& R_{S,t-i}\right)$ are included into Equation (2) and Equation (4) and become Equation (10) and Equation (12), respectively. Equation (11) and Equation (13) consist of lagged CPO futures and spot returns in the square form $\left(R^2_{F,t-i} \& R^2_{S,t-i}\right)$ to capture feedback in variance between both CPO returns. These augmented equations are improved because they have a better description of the temporal dynamics of CPO data.

$$R_{S,t} = a_0 + \sum_{i=1}^{P1} a_i R_{S,t-i} + \sum_{i=1}^{P2} b_i R_{F,t-i} + \varepsilon_{S,t}, \quad \varepsilon_{S,t} | \phi_{t-1} \sim N(0, \sigma^2_{S,t}) \tag{10}$$

$$\sigma^2_{S,t} = w + \sum_{i=1}^{P3} \alpha_i \varepsilon^2_{S,t-i} + \sum_{i=1}^{P4} \beta_i \sigma^2_{S,t-i} + \sum_{i=1}^{P5} R^2_{F,t-i} \tag{11}$$

$$R_{F,t} = a_0 + \sum_{i=1}^{P6} a_i R_{F,t-i} + \sum_{i=1}^{P7} b_i R_{S,t-i} + \varepsilon_{F,t}, \quad \varepsilon_{F,t} | \phi_{t-1} \sim N(0, \sigma^2_{F,t}) \tag{12}$$

$$\sigma^2_{F,t} = w + \sum_{i=1}^{P8} \alpha_i \varepsilon^2_{F,t-i} + \sum_{i=1}^{P9} \beta_i \sigma^2_{F,t-i} + \sum_{i=1}^{P10} R^2_{S.t-i} \tag{13}$$

The sample CCFs of standardized squared residuals at a specific lag k are obtained from above equations and emphasized to be used further in searching th**e** existence of the lead-lag pattern of interaction between CPO spot and futures returns. The significance of these correlations suggests that participants evaluate, assimilate and reflect the arrival of new information in the market, thereby affecting changes of the market volatility.

6. Empirical Results

During the bear market for gold, ACF, PACF and the minimum SIC indicate that conditional mean and variance of CPO spot returns are well explained by ARMA (5,6)-GARCH (1,1) process. For CPO futures return, it is explained by ARMA (4,4)-GARCH (4,4) process. During the bull market for gold, conditional mean and variance of the CPO spot and futures returns are well explained by ARMA (5,5)-GARCH (4,3) and ARMA (4,2)-threshold GARCH (4,4) process, respectively. These univariate equations are written as Equation (14) - Equation (21).

Gold bear period:

$$R_{S,t} = a_0 + a_1 R_{S,t-1} + \ldots + a_5 R_{S,t-5} + b_1 \varepsilon_{S,t-1} + \ldots + b_6 \varepsilon_{S,t-6} + \varepsilon_{S,t} \quad (14)$$

where $\varepsilon_{S,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{S,t}^2\right)\right.$

$$\sigma_{S,t}^2 = w + \alpha_1 \varepsilon_{S,t-1}^2 + \beta_1 \sigma_{S,t-1}^2 \quad (15)$$

$$R_{F,t} = a_0 + a_1 R_{F,t-1} + \ldots + a_4 R_{F,t-4} + b_1 \varepsilon_{F,t-1} + \ldots + b_4 \varepsilon_{F,t-4} + \varepsilon_{F,t} \quad (16)$$

where $\varepsilon_{F,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{F,t}^2\right)\right.$

$$\sigma_{F,t}^2 = w + \alpha_1 \varepsilon_{F,t-1}^2 + \ldots + \alpha_4 \varepsilon_{F,t-4}^2 + \beta_1 \sigma_{F,t-1}^2 + \ldots + \beta_4 \sigma_{F,t-4}^2 \quad (17)$$

Gold bull period:

$$R_{S,t} = a_0 + a_1 R_{S,t-1} + \ldots + a_5 R_{S,t-5} + b_1 \varepsilon_{S,t-1} + \ldots + b_5 \varepsilon_{S,t-5} + \varepsilon_{S,,t} \quad (18)$$

where $\varepsilon_{S,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{S,t}^2\right)\right.$

$$\sigma_{S,t}^2 = w + \alpha_1 \varepsilon_{S,t-1}^2 + \ldots + \alpha_3 \varepsilon_{S,t-3}^2 + \beta_1 \sigma_{S,t-1}^2 + \ldots + \beta_4 \sigma_{S,t-4}^2 \quad (19)$$

$$R_{F,t} = a_0 + a_1 R_{F,t-1} + \ldots + a_4 R_{F,t-4} + b_1 \varepsilon_{F,t-1} + b_2 \varepsilon_{F,t-2} + \varepsilon_{F,t} \quad (20)$$

where $\varepsilon_{F,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{F,t}^2\right)\right.$

$$\sigma_{F,t}^2 = w + \theta_1 D + \alpha_1 \varepsilon_{F,t-1}^2 + \ldots + \alpha_4 \varepsilon_{F,t-4}^2 + \beta_1 \sigma_{F,t-1}^2 + \ldots + \beta_4 \sigma_{F,t-4}^2 \quad (21)$$

The maximum likelihood estimates and diagnostic statistics of the selected univariate equations are summarized in Table 3. One should note from Table 3 that ARCH and GARCH terms under both trends in the gold market are found to be significant. The sum of their coefficients is approximate to unity, suggesting that volatility persistence of both CPO returns is high and stationary. More importantly, Ljung-Box Q test on squared standardized residuals (Q^2 (10)) and ARCH-LM test imply that these selected equations adequately account a serial correlation of the data in the first and second moments in order to produce stationarity of standardized residuals in level and square forms.

As observed in Table 4, during the bear market for gold, a cross-correlation between CPO futures and spot returns of 0.902 at lag 0 is statistically significant at the 1% level. This reveals an evidence of feedback in mean that runs contemporaneously between both CPO returns. In addition, a significant correlation of 0.0797 at the 5% level is interpreted as the mean of current CPO futures causes the mean of CPO spot after 4 days. Since feedback effects in mean at lag 0 and lag 4 provide significant cross-correlations of both CPO returns, both lagged terms of CPO futures returns are then inserted into Equation (14) to become Equation (22). To capture the occurrence of feedback in variance contemporaneously with a significant correlation of 0.7724 at the 1% level, the lag 0 of squared CPO futures return is incorporated into Equation (15) to become Equation (23).

Under the same gold market trend, Table 4 shows that past mean of CPO spot return is correlated with the current mean of CPO futures return at lag 0 and lag 11, where the correlation of 0.9020 at lag 0 and correlation of 0.0718 at lag 11 are significant at the 1% and 5% levels, respectively. To capture both correlations, lag 0 and lag 11 of CPO spot returns are included in Equation (16) to become Equation (24). At the 1% level, a correlation of 0.0997 at lag 1 indicates that the variance of past CPO spot return requires 1 day affecting the variance of current CPO futures return. This dynamic correlation is taken into account together with the contemporaneous correlation by incorporating at lag 0 and lag 1 of squared CPO spot returns into Equation (17) to become Equation (25).

Table 3: Maximum likelihood estimates of the univariate equations

	Gold bear: Jan 17,1996 - Jul 20, 1999		Gold bull: Nov 7, 2005 - Nov 30, 2011	
Parameter	CPO spot	CPO futures	CPO spot	CPO futures
Conditional mean equation:				
a_0	2.02×10^{-6}	3.32×10^{-6}	0.0002	0.0006
	(2.07×10^{-5})	(0.0005)	(0.0002)	(0.0004)
a_1	0.9084**	0.1916**	0.1148**	0.7121***
	(0.0240)	(0.0959)	(0.0584)	(0.0325)
a_2	0.2425**	-0.0223	-0.0795	-0.8943***
	(0.0305)	(0.0835)	(0.0500)	(0.0367)
a_3	0.6011**	0.4758***	0.0295	-0.049
	(0.0289)	(0.0840)	(0.0553)	(0.0331)
a_4	-0.8667**	-0.6201***	-0.1978***	0.0583**
	(0.0276)	(0.0667)	(0.0481)	(0.0260)
a_5	0.0871**	-	0.8872***	-
	(0.0245)		(0.0561)	
b_1	-0.8385**	-0.1636*	-0.1268**	-0.7288***
	(0.0047)	(0.0978)	(0.0644)	(0.0191)
b_2	-0.2765**	0.0515	0.0961*	0.9663***
	(0.0112)	(0.0883)	(0.0541)	(0.0213)
b_3	-0.6497**	-0.4541***	0.0014	-
	(0.0092)	(0.0897)	(0.0589)	
b_4	0.7953**	0.6203***	0.2339***	-
	(0.0067)	(0.0732)	(0.0527)	
b_5	-0.01	-	-0.8930***	-
	(0.0068)		(0.0637)	
b_6	0.0224**	-	-	-
	(0.0083)			
Conditional variance equation:				
w	9.99×10^{-6}**	1.80×10^{-5}**	6.04×10^{-3}*	3.15×10^{-6}**
	(3.2×10^{-6})	(7.71×10^{-6})	(3.3×10^{-8})	(1.4×10^{-6})
θ_1	-	-	-	0.0170*
				(0.0088)
α_1	0.1274**	0.1317***	0.1078***	0.0618***
	(0.0279)	(0.0257)	(0.0184)	(0.0181)
α_2	-	0.1104***	0.0023	0.0506***
		(0.0282)	(0.0295)	(0.01485)
α_3	-	0.1040***	-0.1086***	0.074***
		(0.0271)	(0.0218)	(0.0172)
α_4	-	0.1064***	-	0.0728***
		(0.0283)		(0.0203)
β_1	0.8364**	-0.1014***	1.1106***	0.4974***
	(0.0335)	(0.0332)	(0.0300)	(0.0390)
β_2	-	-0.1190***	-0.27556***	0.0412
		0.0299)	(0.0513)	(0.0308)
β_3	-	-0.1540***	0.9711***	-0.6367***
		(0.0289)	(0.0458)	(0.0319)
β_4	-	0.8579***	-0.8078***	0.8377***
		(0.0275)	(0.0318)	(0.0346)
Log-likelihood	2389.9340	2450.5710	4082.0500	4031.7130
ARCH-LM	0.0927 [0.7608]	2.5611 [0.6337]	0.9958 [0.8023]	1.4099 [0.8425]
$Q^2(10)$	6.6185 [0.1570]	9.5895 [0.4770]	5.78 [0.3280]	7.8009 [0.4530]

Notes: ***, ** and * denote significance level at the 1%, 5% and 10%, respectively. Standard errors and p-values are reported into ( ) and [ ], respectively.

During the bull market for gold, the empirical result in Table 4 shows that CPO spot and futures returns exhibit contemporaneous correlation in mean and variance with significant correlations of 0.8366 and 0.6294 at the 1% level, respectively. Additionally, feedback in mean is found to run from current CPO futures return to future CPO spot return at lag 1, providing that a significant cross-correlation of 0.0897 at the 1% level. Based on these findings, lag 0 and lag 1 of CPO futures returns are included into Equation (18). To capture feedback in variance in the same direction, lag 0 of squared CPO futures return is included in Equation (19). Both updated equations are written as Equation (26) and Equation (27).

Based on the past mean of CPO spot and the current mean of CPO futures returns during the bull trend for gold, their cross-correlation of 0.0564 at lag 9 is found as significant at the 5% level. In views of this correlation, lag 9 of CPO spot return is included along lag 0 of CPO spot return into Equation (20) to become Equation (28) to capture the feedback effect in mean from CPO spot return to CPO futures return. For conditional variance perspective, the contemporaneous squared CPO spot return is included into Equation (21) to become Equation (29). The augmented equations are written as below.

Gold bear period:

$$R_{S,t} = a_0 + a_1 R_{S,t-1} + \ldots + a_5 R_{S,t-5} + b_1 \varepsilon_{S,t-1} + \ldots + b_6 \varepsilon_{S,t-6} + b_7 R_{F,t} + b_8 R_{F,t-4} + \varepsilon_{S,t} \tag{22}$$

where $\varepsilon_{S,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{S,t}^2\right)\right.$

$$\sigma_{S,t}^2 = w + \alpha_1 \varepsilon_{S,t-1}^2 + \beta_1 \sigma_{S,t-1}^2 + \beta_2 R_{F,t}^2 \tag{23}$$

$$R_{F,t} = a_0 + a_1 R_{F,t-1} + \ldots + a_4 R_{F,t-4} + b_1 \varepsilon_{F,t-1} + \ldots + b_4 \varepsilon_{F,t-4} + b_5 R_{S,t} + b_6 R_{S,t-11} + \varepsilon_{F,t} \tag{24}$$

where $\varepsilon_{F,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{F,t}^2\right)\right.$

$$\sigma_{F,t}^2 = w + \alpha_1 \varepsilon_{F,t-1}^2 + \ldots + \alpha_4 \varepsilon_{F,t-4}^2 + \beta_1 \sigma_{F,t-1}^2 + \ldots + \beta_4 \sigma_{F,t-4}^2 + \beta_5 R_{S,t}^2 + \beta_6 R_{S,t-1}^2 \tag{25}$$

Gold bull period:

$$R_{S,t} = a_0 + a_1 R_{S,t-1} + \ldots + a_5 R_{S,t-5} + b_1 \varepsilon_{S,t-1} + \ldots + b_5 \varepsilon_{S,t-5} + b_6 R_{F,t} + b_7 R_{F,t-1} + \varepsilon_{S,,t} \tag{26}$$

where $\varepsilon_{S,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{S,t}^2\right)\right.$

$$\sigma_{S,t}^2 = w + \alpha_1 \varepsilon_{S,t-1}^2 + \ldots + \alpha_3 \varepsilon_{S,t-3}^2 + \beta_1 \sigma_{S,t-1}^2 + \ldots + \beta_4 \sigma_{S,t-4}^2 + \beta_5 R_{F,t}^2 \tag{27}$$

$$R_{F,t} = a_0 + a_1 R_{F,t-1} + \ldots + a_4 R_{F,t-4} + b_1 \varepsilon_{F,t-1} + b_2 \varepsilon_{F,t-2} + b_3 R_{S,t} + b_4 R_{S,t-9} + \varepsilon_{F,t} \tag{28}$$

where $\varepsilon_{F,t} \left| \phi_{t-1} \sim N\left(0, \sigma_{F,t}^2\right)\right.$

$$\sigma_{F,t}^2 = w + \theta_1 D + \alpha_1 \varepsilon_{F,t-1}^2 + \ldots + \alpha_4 \varepsilon_{F,t-4}^2 + \beta_1 \sigma_{F,t-1}^2 + \ldots + \beta_4 \sigma_{F,t-4}^2 + \beta_5 R_{S,t}^2 \tag{29}$$

Table 4: Cross-correlation in the levels and squares of standardized residuals resulting from Table 3

Lag (i)	Gold bear : Jan 17, 1996 - Jul 20, 1999				Gold bull : Nov 7, 2005 - Nov 30, 2011			
	Level		Square		Level		Square	
	S(-i)→F	F→S(+i)	S(-i)→F	F→S(+i)	S(-i)→F	F→S(+i)	S(-i)→F	F→S(+i)
0	0.9020***		0.7724***		0.8366***		0.6294***	
1	0.0546	0.0211	0.0997***	0.0102	-0.0065	0.0897***	0.0141	0.0197
2	-0.0112	-0.0169	-0.0186	-0.0052	0.0110	0.0140	0.0105	-0.0019
3	-0.0253	0.0384	0.0321	0.0142	-0.0082	-0.0226	-0.0157	0.0151
4	0.0300	0.0797**	0.0316	0.0333	0.002	-0.0049	0.0099	0.0132
5	0.0383	0.0355	-0.035	-0.0354	0.0070	0.0028	0.0447	0.0510
6	-0.0088	-0.0348	-0.0309	-0.0109	-0.0102	-0.0013	-0.0133	-0.0069
7	0.0396	0.0309	0.0336	-0.0271	0.0338	0.0126	-0.0011	0.0280
8	0.0556	-0.0005	-0.0347	-0.0396	0.0148	0.0102	-0.0195	-0.0319
9	0.0141	0.0108	-0.012	0.0241	0.0564**	0.0241	-0.0321	0.0073
10	-0.0362	-0.0319	0.0328	0.0513	0.0058	0.0292	0.0192	0.0199
11	0.0718**	0.0272	-0.0156	-0.0221	0.0007	-0.0058	0.0307	0.0284
12	0.0343	0.0158	-0.013	0.0083	0.0343	0.0202	-0.0005	-0.0001
13	0.0013	-0.0242	-0.0177	-0.0068	-0.0216	-0.0329	-0.0344	0.0166
14	0.0630	0.0567	0.0511	0.0151	0.0026	-0.0278	-0.0326	0.0018
15	0.0611	0.0440	0.0325	0.0313	0.0270	0.0486	0.036	0.0149
16	0.0435	0.0193	0.0074	0.0407	0.0415	0.0484	-0.0356	-0.0296
17	0.0125	-0.0340	0.0098	0.0647	0.0357	0.0241	0.0163	-0.0192
18	0.0439	0.0246	-0.0550	-0.0305	0.0039	0.0173	0.0037	-0.0065
19	0.0530	0.0123	-0.0484	-0.0287	0.0045	-0.0043	-0.0077	0.0074
20	0.0634	-0.0040	0.0108	-0.0142	0.0140	0.0178	-0.0202	-0.0004

Notes: S and F denote as daily CPO spot and futures returns. Critical values at 1% are ± 2.58 and critical values at 5% are ± 1.96. *** and ** indicate statistical significance at the 1% and 5% levels, respectively. "S(-i)→F" represents cross-correlations for lag-effect of past daily CPO spot return on current daily CPO futures return, while "F→S(+i)" represents cross-correlations for lead-effect of current daily CPO futures return on future daily CPO spot return. The significant cross-correlation in "Levels" column reveals evidence of feedback effect in mean of two series. In the "Squares" column, it reveals as evidence of feedback effect in variance.

Based on the maximum likelihood estimated augmented equations (Equation (22) - Equation (29)) in Table 5, log-likelihood values of these equations are higher than univariate equations. This suggests that the inclusion of these lagged terms of CPO returns significantly increase the explanatory power of augmented estimated models, where it is further dictated by the Ljung-Box Q and ARCH-LM diagnostic statistics in terms of its adequacy.

Table 5: Maximum likelihood estimates of the augmented equations

	Gold bear: Jan 17,1996 - Jul 20, 1999		Gold bull: Nov 7, 2005 - Nov 30, 2011	
Parameter	CPO spot	CPO futures	CPO spot	CPO futures
Conditional mean equation:				
a_0	-1.34 x 10^{-5}	8.88 x 10^{-5}	2.75 x 10^{-6}	0.0001
	(1.8 x 10^{-5})	(0.0001)	(0.0001)	(9.59 x 10^{-5})
a_1	0.036***	-0.0128	-0.7859***	-0.0339**
	(0.0112)	(0.0122)	(0.1795)	(0.0124)
a_2	0.0039	0.0185**	0.0718***	0.0417**
	(0.0064)	(0.0090)	(0.0218)	(0.0131)
a_3	-0.0036	0.0179	-0.0107	-0.0119
	(0.0067)	(0.0128)	(0.0156)	(0.0109)
a_4	0.7503***	0.0076	0.0142	-0.0021
	(0.0832)	(0.0104)	(0.0127)	(0.011)
a_5	-0.0228*	-	0.013439	-
	(0.0121)		(0.0119)	
b_1	-0.1164***	-0.015	0.4631***	-0.2627***
	(0.0402)	(0.0402)	(0.179)	(0.0312)
b_2	-0.057*	-0.0067	-0.3919***	-0.0538*
	(0.0326)	(0.0345)	(0.0805)	(0.0295)
b_3	-0.0359*	-0.0122	-0.0534	0.9595***
	(0.0216)	(0.0275)	(0.0347)	(0.0121)
b_4	-0.7990***	-0.0429	-0.0517	-0.0207*
	(0.0719)	(0.0257)	(0.0321)	(0.0117)
b_5	0.0981**	0.939***	-0.0308	-
	(0.0396)	(0.013)	(0.0252)	
b_6	0.0373	0.0185*	0.8498***	-
	(0.0283)	(0.0097)	(0.0124)	
b_7	0.9587***	-	0.7485***	-
	(0.0118)		(0.1521)	
b_8	-0.7261***	-	-	-
	(0.0775)			
Conditional variance equation:				
w	4.8 x 10^{-6}***	5.43 x 10^{-6}***	1.2 x 10-6***	4.6 x 10^{-7}**
	(6.7 x 10^{-7})	(1.44 x 10^{-6})	(3.2 x 10^{-7})	(1.8 x 10^{-7})
θ_1	-	-	-	-0.0062
				(0.0086)
α_1	0.6001***	0.4116***	0.4517***	0.4204***
	(0.0657)	(0.0559)	(0.0513)	(0.0458)
α_2	-	-0.0086	-0.1964***	-0.0212***
		(0.0526)	(0.0715)	(0.006)
α_3	-	0.1049***	-0.1343**	0.0549***
		(0.0252)	(0.0606)	(0.0073)
α_4	-	-0.1823***	-	-0.3865***
		(0.035)		(0.0392)

Notes: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors are reported into ( ).

Table 5: (Continued)

	Gold bear: Jan 17,1996 - Jul 20, 1999		Gold bull: Nov 7, 2005 - Nov 30, 2011	
Parameter	CPO spot	CPO futures	CPO spot	CPO futures
Conditional variance equation (continued):				
β_1	0.1796*** (0.0356)	0.1258 (0.1426)	0.5467*** (0.1443)	0.1923*** (0.0407)
β_2	0.0349*** (0.0045)	-0.2759*** (0.0601)	0.2806* (0.1463)	-0.0855*** (0.011)
β_3	-	0.4124*** (0.0801)	-0.0714** (0.03)	0.8831*** (0.0133)
β_4	-	0.0075 (0.044)	-0.0113 (0.0192)	-0.1171*** (0.036)
β_5	-	0.0285*** (0.0039)	0.0313*** (0.0041)	0.0184*** (0.0016)
β_6	-	0.0095 (0.0061)	-	-
Log-likelihood	3310.4220	3292.0640	5217.8420	5124.4540
ARCH-LM	0.6243 [0.4295]	0.4195 [0.9808]	1.4846 [0.6858]	1.0902 [0.8958]
$Q^2(10)$	4.5465 [0.3370]	1.5693 [0.9550]	3.1481 [0.6770]	9.4281 [0.3070]

Notes: ***, ** and * indicate statistical significance at the 1%, 5% and 10% levels, respectively. Standard errors and p-values are reported into ( ) and [ ], respectively.

After capturing the interaction of CPO spot and futures returns, volatility persistence for the respective CPO return and sample CCFs of standardized residuals (level and square forms) from lag 0 to lag 20 are summarized in Table 6 and Table 7, respectively. Their results of spillover effects in mean and volatility are further used to test *Hypothesis 1* and *Hypothesis 2*.

Based on Table 6 and Table 7, there are three findings to support *Hypothesis 1* during the upward trend of the gold market. First, the included current squared CPO futures return in Equation (27) is found to absorb a large portion of volatility persistence for CPO spot return by 0.1343 (as shown in Table 6, it reduces from 0.9999 to 0.8656). Second, the variation of current CPO futures return takes 20 days to increase variation of future CPO spot return ("Squares" column in Table 7). Third, a correlation of 0.1141 between standardized squared residuals of CPO spot and futures returns at the lag of 20 days is significant at the 1% level ("Squares" column in Table 7). These findings suggest that market participants who have a bullish expectation on gold price tend to expect that inflationary pressure will increase volatility in the CPO futures market. Hence, their attention would turn to CPO futures returns to predict CPO spot returns.

Table 6: Volatility persistence of CPO spot and futures returns

	Model specification		Univariate equation			Augmented equation		
	Conditional mean	Conditional variance	Sum of GARCH	Sum of ARCH	Sum	Sum of GARCH	Sum of ARCH	Sum
Gold bear: Jan 17,1996 - Jul 20, 1999								
S	ARMA(5,6)	GARCH(1,1)	0.8364	0.1274	0.9638	0.1796	0.6000	0.7797
F	ARMA(4,4)	GARCH(4,4)	0.4835	0.4525	0.9360	0.2697	0.3257	0.5954
Gold bull: Nov 7, 2005 - Nov 30, 2011								
S	ARMA(5,5)	GARCH(4,3)	0.9983	0.0016	0.9999	0.7445	0.1210	0.8656
F	ARMA(4,2)	TGARCH(4,4)	0.7396	0.2593	0.9988	0.8727	0.0675	0.9402

Notes: S and F denote as daily CPO spot and futures returns. TGARCH stands for threshold GARCH model. Volatility persistence is measured through the sum of coefficient values for ARCH and GARCH terms.

Table 7: Cross-correlation in the levels and squares of standardized residuals resulting from Table 5

Lag (i)	Gold bear : Jan 17,1996 - Jul 20, 1999				Gold bull : Nov 7, 2005 - Nov 30, 2011			
	Level		Square		Level		Square	
	S(-i)→F	F→S(+i)	S(-i)→F	F→S(+i)	S(-i)→F	F→S(+i)	S(-i)→F	F→S(+i)
0	-0.9120***		0.7313***		-0.8731***		0.7181***	
1	0.0322	-0.0275	-0.0003	-0.0271	0.0015	-0.0309	-0.0138	-0.0050
2	0.0025	-0.0249	-0.0172	-0.0242	-0.0326	-0.0625**	-0.0200	-0.0202
3	-0.0142	-0.0250	0.0206	-0.0165	0.0205	-0.0244	-0.0052	0.0067
4	-0.0047	-0.0034	-0.0070	0.0039	0.0196	-0.0030	-0.0199	-0.0207
5	-0.0330	-0.0294	0.0078	-0.0192	0.0455	-0.0198	0.0378	0.0051
6	0.0680**	0.0426	-0.0116	0.0009	-0.0198	-0.0383	-0.0340	-0.0195
7	0.0222	0.0032	0.0132	-0.0224	0.0316	0.0194	-0.0175	-0.0196
8	0.0330	-0.0114	0.0178	-0.0112	0.0211	0.0313	-0.0015	-0.0295
9	-0.0120	-0.0066	-0.0124	-0.0145	0.0700***	0.0482	-0.0291	-0.0154
10	-0.0478	-0.0228	-0.0007	-0.0369	0.0200	0.0623**	-0.0193	-0.0203
11	0.0006	-0.0228	-0.0048	-0.0143	0.0189	0.0220	-0.0103	-0.0204
12	-0.0020	-0.0228	-0.0278	-0.0173	0.0127	0.0015	-0.0294	-0.0111
13	0.0568	0.0491	-0.0230	-0.0214	-0.0153	-0.0016	-0.0057	-0.0234
14	-0.0277	-0.0167	-0.0211	-0.0219	0.0202	0.0100	-0.0028	-0.0104
15	-0.0233	-0.0079	0.0111	0.0245	-0.0183	0.0018	-0.0120	0.0042
16	0.0297	-0.0163	-0.0243	0.0292	-0.0136	0.0032	-0.0254	-0.0210
17	0.0216	0.0329	0.0044	0.0134	-0.0048	-0.0190	-0.0042	-0.0011
18	-0.0164	0.0028	-0.0011	0.0397	0.0046	0.0157	0.0100	-0.0103
19	-0.0742**	-0.0431	0.0307	-0.0060	0.0007	0.0193	-0.0004	-0.0084
20	-0.0012	-0.0206	0.0028	0.0209	-0.0583	-0.0404	0.0325	0.1141***

Notes: S and F denote as daily CPO spot and futures returns. Critical values at 1% are ± 2.58 and critical values at 5% are ± 1.96. *** and ** indicate statistical significance at the 1% and 5% levels, respectively. "S(-i)→F" represents cross-correlations for lag-effect of past daily CPO spot return on current daily CPO futures return, while "F→S(+i)" represents cross-correlations for lead-effect of current daily CPO futures return on future daily CPO spot return. The significant cross-correlation in "Levels" column reveals evidence of mean dependence of two series. In the "Squares" column, it reveals as evidence of variance dependence.

The result from Table 6 and Table 7 supports *Hypothesis 2* that posits market participants who are a bearish expectation on gold price tend to react faster to the arrival of new information on CPO spot-futures returns following three findings. First, the incorporating lag 0 and lag 1 of squared CPO spot returns as explanatory variables in Equation (25) sharply reduce volatility persistence for CPO futures return by 0.3406 (as shown in Table 6, it reduces from 0.9360 to 0.5954). Second, market participants' response to volatility in CPO spot market towards the futures market contributes to a significant contemporaneous correlation of 0.7313 between standardized squared residuals of both CPO returns at the 1% level ("Squares" column in Table 7). Third, the contemporaneous correlation of 0.7313 during the gold bear market is slightly stronger than a significant contemporaneous correlation of 0.7181 during the gold bull market ("Squares" column in Table 7), suggesting that market participants who have a bearish expectation on gold price are risk averse in responding volatility in the CPO futures market based on CPO spot volatility.

7. Conclusion

Our study proposes the hypothesis that expected inflationary shock as reflected by the movement of higher gold prices or bullish on a longer time horizon would raise the speculative pressure in the determination of future CPO price. As a consequence, CPO futures will rise above CPO spot, the futures volatility will be higher than the spot volatility, resulting in lower storage demand and the option value of keeping the inventory, investors will take long positions in CPO futures to cover a high marginal cost in the future. This theoretical exposition is supported by our empirical findings that there will be dynamic information spillover from current CPO futures return to spot return during the gold bullish trend, in addition to the presence of contemporaneous information spillover.

We further propose the hypothesis that during the period of deflation shock as shown by the bearish trend in gold prices, there will be less speculative pressure on future CPO price. Instead, there will be a strong contemporaneous correlation between CPO spot and futures returns as shown from our empirical result. This study adds to another stylized fact that the upward movement of gold prices has economic content and will be able to cause speculation of CPO prices through the futures market. If the above hypotheses are true, speculators will not only affect the CPO spot prices during contango, they may also respond to CPO futures prices by predicting CPO spot prices based on their bullish expectation on gold prices as a signal of inflation hedge.

Based on the finding, this study suggests the following policy implications: Firstly, the upward movement of gold price will be an indicative of a future rise in CPO price. To speculate on the increase in the price of CPO, investors can long CPO futures contracts to insulate them from a high inflation. Secondly, when CPO price is expected to fall, the downward movement of gold price would be a signal for the investors to implement short-selling activities.

References

Beckmann, J., & Czudaj, R. (2013). Gold as an inflation hedge in a time-varying coefficient framework. *The North American Journal of Economics and Finance, 24*, 208-222.

Bos, J. W., & Van der Molen, M. (2012). *A bitter brew? Futures speculation and commodity prices* (METEOR Research Memorandum No. 044). Retrieved from Maastricht University website: https://cris.maastrichtuniversity.nl/portal/files/753202/guid-f6624133-fd80-411b-ae3d-f8ff5c2916a6-ASSET1.0

Cheung, Y. M., & Ng, L. K. (1996). A causality in variance test and its application to financial market prices. *Journal of Econometrics,* 72(1), 33-48.

Davidson, R., & MacKinnon, J. G. (2004). *Econometric theory and methods.* New York, NY: Oxford University Press.

Enders, W. (2010). *Applied Econometric Time Series* (3rd ed.). New Jersey, NY: John Wiley & Sons.

European Biodiesel Board. (2007). *The EU Biodiesel Industry Statistics.* Retrieved on May 13, 2016, from http://www.ebb-eu.org/stats.php.

Ghazali, M. F., Lean, H. H., & Bahari, Z. (2013). Is gold a hedge or a safe haven? An empirical evidence of gold and stocks in Malaysia. *International Journal of Business and Society, 14*(3), 428-443.

Ghazali, M. F., Lean, H. H., & Bahari, Z. (2015). Is gold a good hedge against inflation? Empirical evidence in Malaysia? *Kajian Malaysia, 33*(1), 69-84.

Go, Y. H., & Lau, W. Y. (2017). Investor demand, market efficiency and spot-futures relation: Further evidence from crude palm oil. *Resources Policy*, *53*, 135-146.

Gulley, A, & Tilton, J. E. (2014). The relationship between spot and futures prices: An empirical analysis. *Resources Policy, 41*, 109-112.

Henry, O. T., Olekalns, N., & Lakshman, R.W.D. (2007). Identifying interdependencies between South-East Asian stock markets: A non-linear approach. *Australian Economic Papers, 46*(2), 122-135.

Jaffe, J. F. (1989). Gold and gold stocks as an investment for institutional portfolios. *Financial Analysts Journal, 45*(2), 53-59.

Kaufmann, R. K., & Ullman, B. (2009). Oil prices, speculation, and fundamentals: Interpreting causal relations among spot and futures prices. *Energy Economics, 31*(4), 550-558.

Koizumi, T., & Ohga, K. (2007). Biofuels policies in Asian countries: Impact of the expanded biofuels programs on world agricultural markets. *Journal of Agricultural and Food Industrial Organization, 5*(2), 1-20.

Lean, H. H., & Smyth, R. (2015). Testing for the weak-form efficiency of crude palm oil spot and futures markets: New evidence from a GARCH unit root test with multiple structural breaks. *Applied Economics, 47*(16), 1710-1721.

Ma, C. K., Mercer, J. M., & Walker, M. A. (1992). Rolling over futures contracts: A note. *Journal of Futures Markets*, *12*(2), 203-217.

Mahdavi, S., & Zhou, S. (1997). Gold and commodity prices as leading indicators of inflation: Tests of long-run relationship and predictive performance. *Journal of Economics and Business, 49*(5), 475-489.

Malaysian Palm Oil Board. (2011). *Quarterly Report on Oils and Fats.* Retrieved from http://bepi.mpob.gov.my/images/ Quarterly2011/4th%20Quarter%202011

Malaysian Palm Oil Board. (2015). *Annual Report 2015*. Retrieved from http://bepi.mpob.gov.my/images/overview/Overview_of_Industry_2015.pdf

Ministry of Agricultural and Agro-Based Malaysia. (2014). *National Agro-Food Policy*. Retrieved from http://www.kada.gov.my/en/web/guest/dasar-agro-makanan-negara

Narayan, P. K., Narayan, S., & Zheng, X. (2010). Gold and oil futures markets: Are market efficient? *Applied Energy, 87*(10), 3299-3303.

Newberry, D. M. (1992). Futures markets: Hedging and speculation. In P. Newman, M. Milgate & J. Eatwell (Eds.), *The new Palgrave dictionary of money and finance (*Vol.2, pp. 207-210). London, UK: Macmillan.

Oil World. (2010). Oil World Statistical Update, Hamburg, West Germany, various issues.

Performance Management and Delivery Unit. (2010). *Economic Transformation Programme: A Roadmap for Malaysia - Deepening Malaysia's Palm Oil Advantage*. Retrieved from http://etp.pemandu.gov.my/upload/etp_handbook_chapter_9_palm_oil.pdf

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335-346.

Pindyck, R. (2001). The dynamics of commodity spot and futures market: A primer. *Energy Journal, 22*(3), 1-29.

Shahbaz, M., Tahir, M. I., Ali, I., & Rehman, I. U. (2014). Is gold investment a hedge against inflation in Pakistan? A co-integration and causality analysis in the presence of structural breaks. *The North American Journal of Economics and Finance*, *28*, 190-205.

Tilton, J. E., Humphreys, D., & Radetzki, M. (2011). Investor demand and spot commodity prices. *Resources Policy, 37*(3), 187-195.

Twomey, J., Foran, J., & Brosnan, C. (2011). Assessing managed futures as an inflation hedge within a multi-asset framework. *Journal of Wealth Management, 14*(3), 33-43.

Unites States Department of Agriculture Foreign Agricultural Service (2014). *Malaysia Biofuels Annual 2014* (GAIN Report Number: MY4011). Retrieved from https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Biofuels%20Annual_Kuala%20Lumpur_Malaysia_6-25-2014.pdf

Zhang, Y. J., & Wei, Y. M. (2010). The crude oil market and the gold market: Evidence for cointegration, causality and price discovery. *Resources Policy, 35*(3), 168-177.